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I, LEANNE MYNOTT, MANAGER EXAMINATION SUPPORT AND SALES hereby certify that annexed is a true copy of the Provisional specification in connection with Application No. 2003902318 for a patent by VISION FIRE AND SECURITY PTY LTD as filed on 14 May 2003.

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Regulation 3.2

Vision Fire and Security Pty Ltd

AUSTRALIA

Patents Act 1990

PROVISIONAL SPECIFICATION

for the invention entitled:

"Improved Sensing Apparatus And Method"

The invention is described in the following statement:

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Improved Sensing Apparatus and Method

The present invention relates to an improved sensing apparatus and method. In particular the present invention relates to an improved particle detector and method for detecting particles from air sampled from a number of locations.

Particle detectors are useful in detecting smoke particles in an airstream, as a means of determining whether a location may contain a thermal event. Sensitive smoke detectors, such as the VESDA LaserPlus sold by Vision Fire and security, detect the number of particles in an airstream. Typical thermal events, such as combustion, produce significant quantities of airborne particles, and therefore detecting these particles is useful in determining whether there may be a thermal event in a particular location. One type of smoke detector uses a network of pipes, each pipe having a number of apertures along its length. The pipe network is connected to a particle detector, and an aspirator draws air through the pipes and into a particle detecting chamber. Using a pipe network, air may be sampled from a number of different points over an area.

An example of a smoke detector in accordance with the present invention is described below wherein:

Figure 1 shows a schematic arrangement of an embodiment of a sensing apparatus;

Figure 2 shows a schematic embodiment of a flow sensor of a sensing apparatus of Figure 1;

Figure 3 shows an embodiment of an integrator circuit and waveform output of a controller of the flow sensor of in Figure 1;

Figure 4 shows a schematic of the components of a controller and flow sensor of the sensing apparatus of figure 1;

Figure 5 shows the waveforms of signals received by the flow sensor of the sensing apparatus of figure 1.

A particle sensor system in the form of a smoke detector 10, shown in figure 1, includes a housing 11 attached to a conduit 28. The detector 10 has a number of component parts including a detector chamber 14, an aspirator 16, a filter 18, a fluid inlet 20 and a fluid outlet 22. For purposes of clarity the precise fluid flow path within the chamber 14 is not shown in figure 1.

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Also associated with the smoke detector 10 is a flow sensor 24. In figure 1 the flow sensor 24 is in fluid communication with the inlet 20 and aspirator 16.

Conduit 26 is connected to a network of pipes 28. Each pipe 28 has a number of sampling points 29. The sampling points 29 allow air to be sampled at various places in an area to be protected, such as a building (not shown). The aspirator 16 draws air into the sampling points 29 through the pipe network 28, through the inlet 20 and into the housing 11. The air sample then passes into the flow sensor 20. A flow disruptor 21 may be located upstream of the flow sensor 20 to remove the laminar flow characteristics of steady air flow through the pipe network.

The aspirator 16 in the sensor 10 draws the sampled air along the pipes 28, through the inlet 20, flow disruptor 21, flow sensor 24 and into the detector 14, where the particles are detected. If the level of particles exceeds a predetermined level, then the sensor 10 may take a number of actions, such as setting off an alarm, activating fire suppression systems or other activities. The sensor 10 is typically in communication with external devices such as a fire panel (not shown). This system is employed in a number of buildings, and a typical system would be a VESDA[tm] Laser Plus system as sold by Vision Fire and Security Pty Ltd, attached to a pipe network.

In one embodiment, the ultrasonic flow sensor has two combined receivers and transmitters, such as US80KS-01 from Measurement Specialties Inc. Each is a piezoelectric transducer connected to a controller 40. The controller 40 includes a generator and receiver, analogue to digital converter and a digital microprocessor. The microprocessor generates a signal in a first direction by exciting transducer 42, generating an ultrasonic acoustic signal which is received by transducer 44, then a signal in a second direction by exciting transducer 44 generating an ultrasonic signal which is received by transducer 42. The microprocessor, in conjunction with the receiver circuitry measures the time taken for the signals to propagate in each direction.

For a propagation time in the first direction of t_1 and a propagation time in the second direction of t_2, the speed of the air flow past the transducers may be calculated as:

$$s = \frac{d}{2}\left(\frac{1}{t_2} - \frac{1}{t_1}\right)$$

where s is the speed of the air and d is the distance between the transducers. It is then a simple matter to calculate flow based given the cross-sectional area A of the flow path. That is, flow f is

$$f = A\frac{d}{2}\left(\frac{1}{t_2}-\frac{1}{t_1}\right)$$

It is possible to determine the propagation time in each of the two aforementioned directions by a number of means, an example of such means being the use of a high-speed electronic digital counter which is triggered by the application of the exciting voltage to the transmitting transducer and halted by the arrival of the received ultrasonic signal at the receiving transducer.

A further example is to use a Digital Signal Processor to sample the received signal using an analog to digital converter and to then calculate the precise arrival time of a signal by detecting a feature in the received signal such as a peak, or combination of peaks or a zero crossing or combination of zero crossings.

The flow sensor is required in order to determine that the air-sampling pipe network is in good order. In a first case, a high flow level indicates that pipe work has become dislodged from the smoke detector or has been broken whereas in a second case, a low flow level indicates some form of pipe blockage. In either of the aforementioned cases, it is likely that the performance of the smoke detection system has become impaired so they must be detected and reported so that corrective measures may be enacted.

Determining the rate of flow through a pipe network can be difficult, and many known types of flow sensor require some part of the sensor to protrude into the airflow. The air sampled in a smoke detection system often contains contaminants such as particles and fibres. These contaminants can cause errors in the flow sensing means of prior art mechanisms. For example, in resistive type devices, such as a constant temperature probe, accumulation of contaminants on the probe changes its heat transfer characteristics. Other flow sensors such as moving vane types also project into the air stream flowing through the pipe or housing of the detector and are also be subject to contamination. Smoke detecting systems may have to be in the field for many years without calibration, and therefore reliable flow sensing is important. Further, smoke detectors must be able to operate in a variety of conditions,

such as a range of temperatures, humidities and pollution. These conditions can affect the performance of the flow meter, affecting the overall performance of the detector.

In another prior-art mechanism, a restriction, such as an orifice or venturi, is interposed within the flow path. A manometer may be used to measure the pressure drop across this restriction which indicates the level of flow. This approach has the disadvantage that it impedes the flow of air and therefore reduces the efficiency of the aspirator causing excessive air transport time delays or reduced area coverage of the sampled smoke detection system overall. This system is also subject to contamination problems as the restriction accumulates dust, fibres and other matter, causing the flow reading to drift from its correct value.

Further, most prior art mechanisms measure the mass-flow of air which is highly sensitive to density variations with temperature and altitude. Thus, such mechanisms require a compensation means for temperature and pressure in accordance with their individual characteristics incurring extra expense and calibration time. The present invention measures volumetric flow which is substantially constant with temperature and is a better measure of pipe work blockage or disconnected pipe work.

Using the proposed ultrasonic flow sensing mechanism, all of these deficiencies are overcome.

a. Ultrasonic flow sensing reports volumetric air flow (litres per minute or equivalent) and is not dependent of pressure or density

b. The transducers are placed outside the airflow path so airborne contaminants are not deposited on the transducers

c. The system has no moving parts and so is not subject to mechanical wear

d. Ultrasonic flow sensing is intrinsically very stable allowing more sensitive detection of flow changes.

One major problem of aspirated smoke detectors is blocking of sample holes. It has been very difficult to detect whether one or more sampling holes are blocked. Traditionally this has been addressed by visually checking the sample holes or regular cleaning, whether required or not. Using an ultrasonic flow sensor it is possible to detect smaller changes in airflow into the detector. As one or more holed become blocked, the airflow into the detector drops, and this is detected by the ultrasonic flow

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sensor. Once the flow of air drops below a predetermined value, the detector may indicate a fault, allowing a user to check the pipe network and sampling holes.

In the preferred embodiment of the invention, an ultrasonic flow sensor in interposed in the air flow path in order to detect any off-normal air flow condition in the air-sampling pipe network smoke detector. In the preferred embodiment, the flow sensor consists of two transducers mounted on opposite sides of the air flow path and offset by a distance in the direction of flow as shown in figures 2 and 4.

A control unit, shown in figure 4, consisting of a driver stage, a receiver amplifier, a detector and microcontroller is incorporated to initiate the excitation of a transmitting transducer and to measure the propagation time of the ultrasonic signal to the receiving transducer.

In the preferred embodiment, the microprocessor is programmed to excite a transducer with five pulses whose repetition rate is 80kHz. The processor is then required to wait for a known blanking time period t_b and then activate the zero-crossing detector circuit. After a further time, t_r, which nominally corresponds to the expected occurrence of, for instance, the third peak of the received signal, the detector circuit is activated and using a dual-slope integrating ramp circuit, determines the time position of the centre of one of the peaks in the received signal relative to the end of t_r. This time t_w is represented by a voltage V_w which is measured by the analog to digital converter on the microprocessor. This voltage is converted to a time by the formula

$$t_w = kV_w$$

where k is a constant readily calculated from the integrator circuit component values.

Therefore the total propagation time, from a known pulse P in the transmission waveform, to the corresponding pulse in the received waveform, is

$$t_p = t_b + t_r + t_w - t_d$$

where t_d is the delay from the start of the waveform to the nominated pulse P

An aspect of the preferred embodiment is that the propagation time measurement uses an early part of the received waveform; usually the third or fourth peak, to determine the arrival time of the pulse. This has the advantage of avoiding phase and amplitude

errors caused by the arrival of echoes and higher order propagation modes which are sensitive to temperature.

A further important aspect of the preferred embodiment is the use of a dual slope integrator to determine the location of the centre of the sinusoidal wave-peak used for the receive timing. This aspect averages the leading and trailing zero crossing times of the nominated wave-peak in order to estimate its centre time. This aspect allows the precise determination if the sinusoidal wave position at very low cost and avoids the need for high-speed counters or high speed sampling and processing schemes. This aspect is explained in more detail below with reference to figures 4 and 5.

The dual slope integrator is a means of estimating the centre time point of a waveform event characterised by a rising edge followed by a falling edge or alternatively, a falling edge followed by a rising edge. For the purposes of clarity of explanation and with reference to figures 3a and 3b, only the case of the rising edge followed by the falling edge will be discussed.

Initially, both flip-flops A and B are in the reset state causing $\overline{Q}$ to be active, thus enabling the two equal value current sources. The integrator is held inactive initially by the de-activation of the enable signal so the RAMP output is zero.

At a time t_{ref}, the ENABLE signal is activated and the RAMP output starts to rise at a rate which is proportional to 2I where I is proportional to a single current source output.

After a time t_f, one of the WAVEFORM asserts a positive edge, thus activating flip-flop A which in turn disables one current source through the control signal CA. This causes the RAMP to slow to a rate half of the previous rate.

After a time t_s, the WAVEFORM asserts a negative edge, activating flip-flop B and consequently disabling the second current source so that no current is being fed into the integrator. The integrator will thus hold the RAMP value at that value that was present at the fall of the WAVEFORM edge.

Thus the RAMP voltage now represents an elapsed time value from t_{ref} shown as t_k where:

$$t_k = t_f + t_s$$

Thus it may be readily seen that the dual slope integrator RAMP final value is proportional to the elapsed time from a reference time to the centre of the WAVEFORM pulse.

Preferably an airflow disruptor ing is situated upstream of the flow sensor 24, to provide a more uniform flow of fluid (air) across the airstream. The flow sensor 24 may be in situated before the air is sampled through the detection chamber 14, or after. The flow sensor 24 may be situated in a number of different locations along the flow path of the air to be sampled. However, for best results in accurately measuring the total flow of the air drawn into the network, the preferred location is at or near the fluid inlet. Figure 1 shows the flow sensor 24 located before the aspirator 16, and after a flow disruptor 20. It has been found that disrupting the flow provides a better estimate of the flow rate as ultrasonic flow detectors appear to average out the flow rate along the pipe if it is not laminar. Laminar flows may be difficult to measure consistently using an ultrasonic flow meter, as the flow profile may change.

Claims:

1 An aspirated smoke detector comprising a particle detector, a sampling network and an aspirator, an inlet, an outlet and a flow sensor, wherein the flow sensor uses ultrasonic waves to detect the flow rate of air entering the particle detector.

2 A method of detecting one or more blocked sampling holes in a pipe of an aspirated smoke detector system comprising:

Ascertaining the base flow of fluid through a particle detector using a flow sensor;

Monitoring subsequent flow through the particle detector;

Comparing the subsequent flow with the base flow, and indicating a fault if the difference between the base flow and the subsequent flow exceeds a predetermined threshold.

3 The method If claim 2wherein the flow sensor is an ultrasonic flow sensor.

4 The method of claim 3 wherein the difference between base flow and subsequent flow is compared over a length of time.

5 The detector of claim 1 wherein the flow sensor measures the partial flow of fluid through a sampling network.

6 The smoke detector of claims 1 or 5 wherein the particle detector detects particles in a portion of the air flow flowing through the sampling network.

7 The smoke detector of any one of claims 1, 5 or 6 wherein the flow sensor is located in the sampling network

8 The smoke detector of any one of claims 1, 5 or 6 wherein the flow sensor is located in a housing for the particle detector

9 The smoke detector of any one of claims 1, 5 or 6 having a branch in the inlet allowing air to bypass the particle detector.

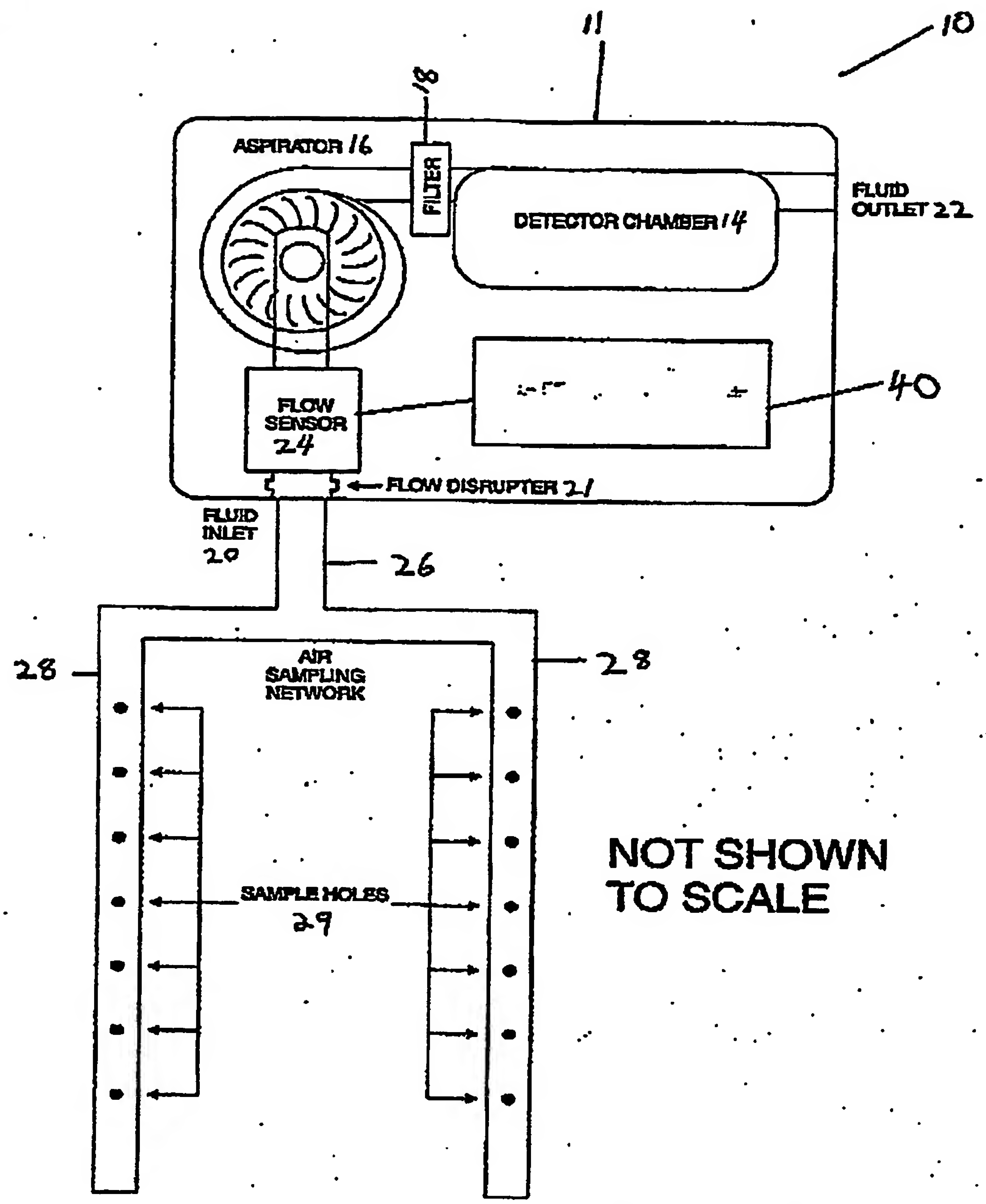

Figure 1

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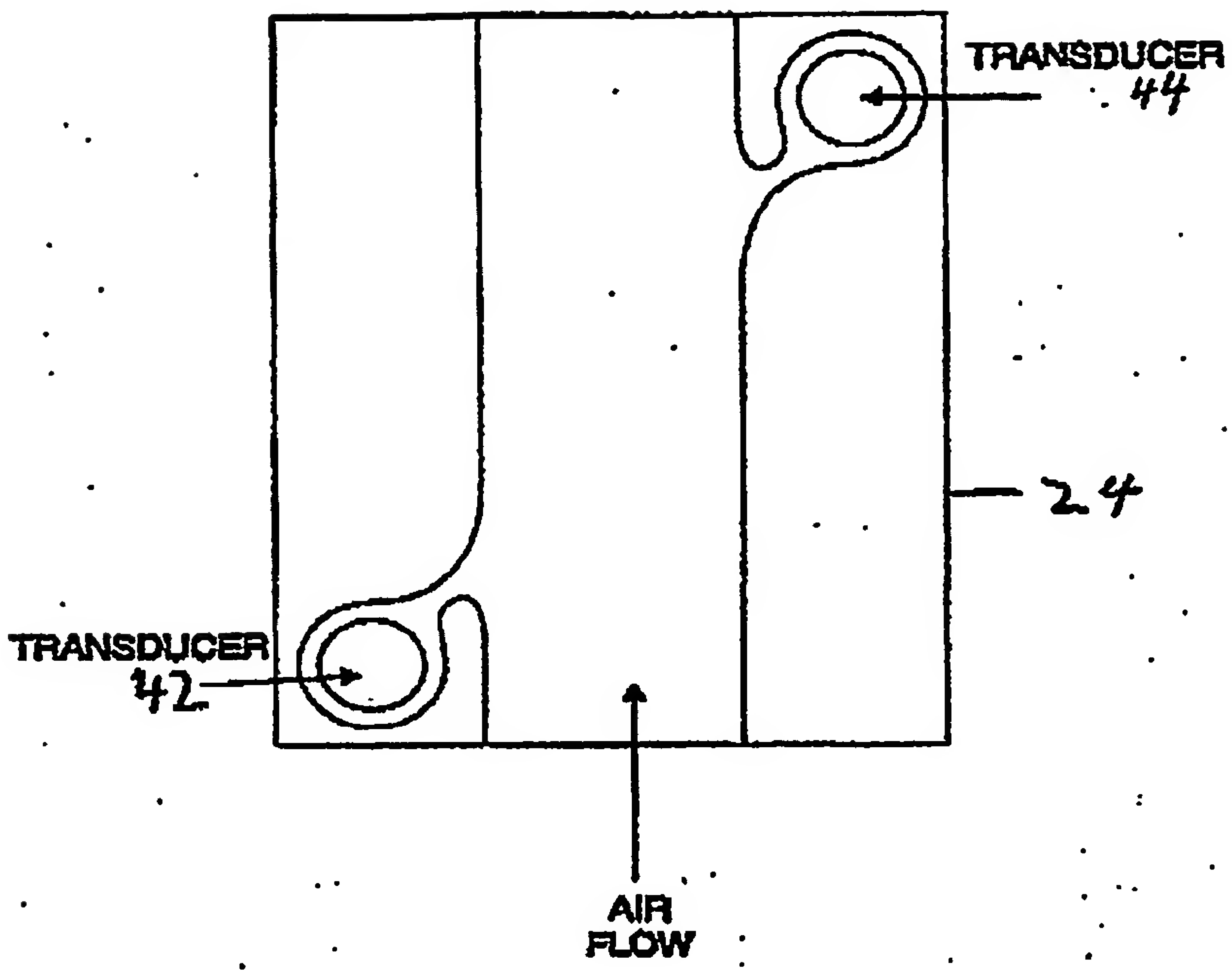

Figure 2

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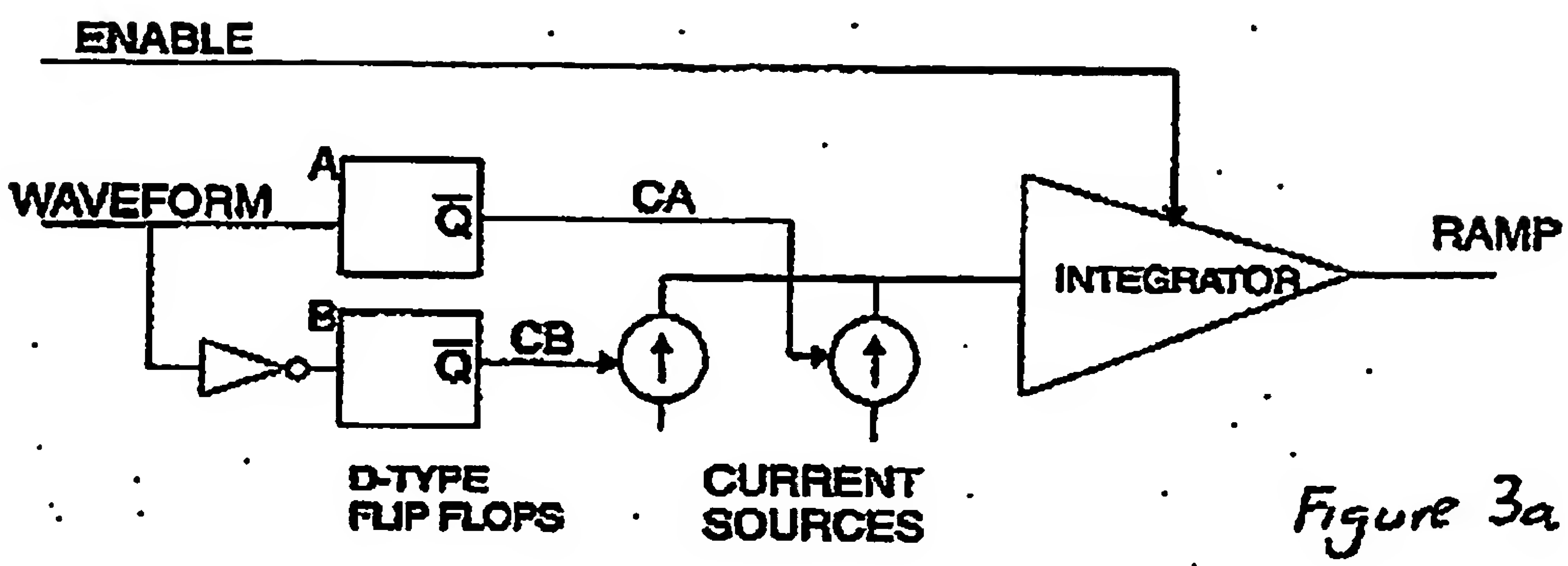

Figure 3a

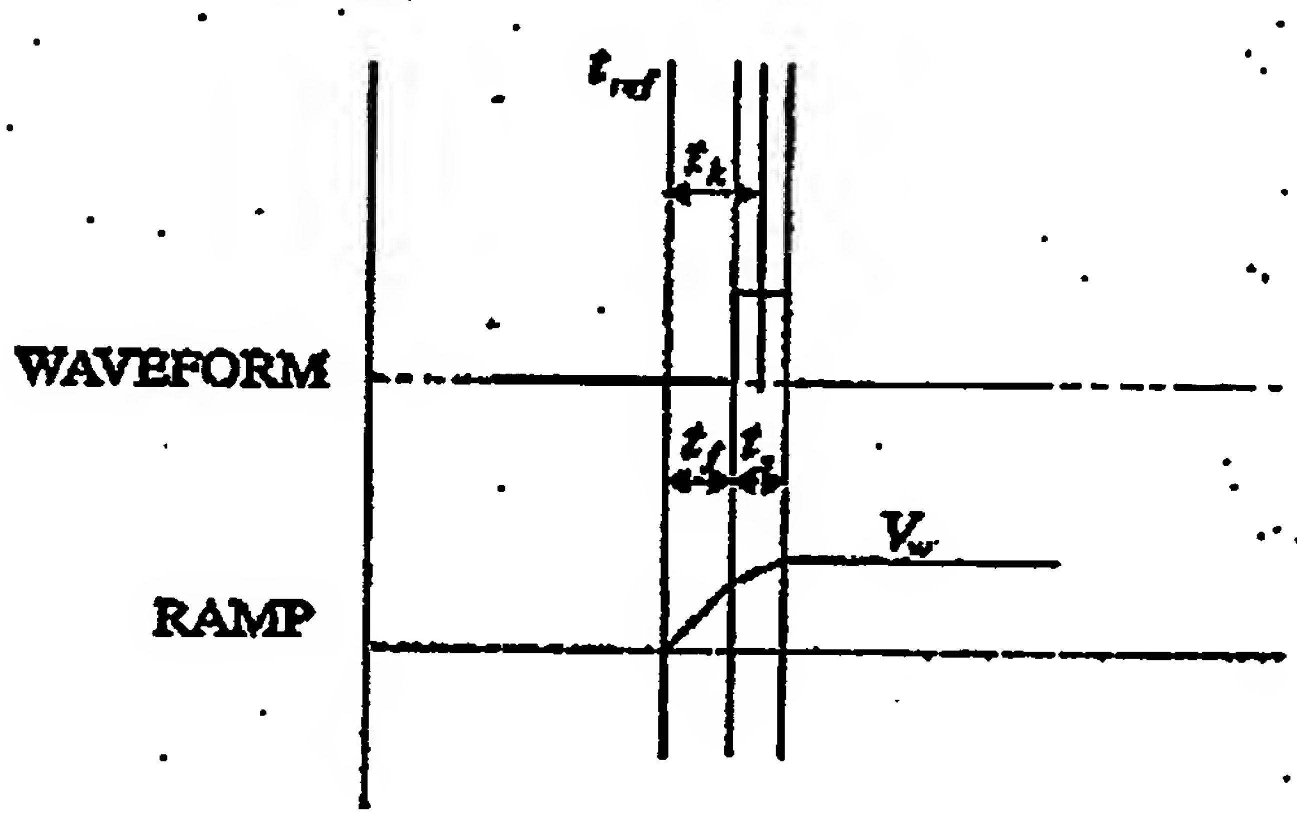

Figure 3b

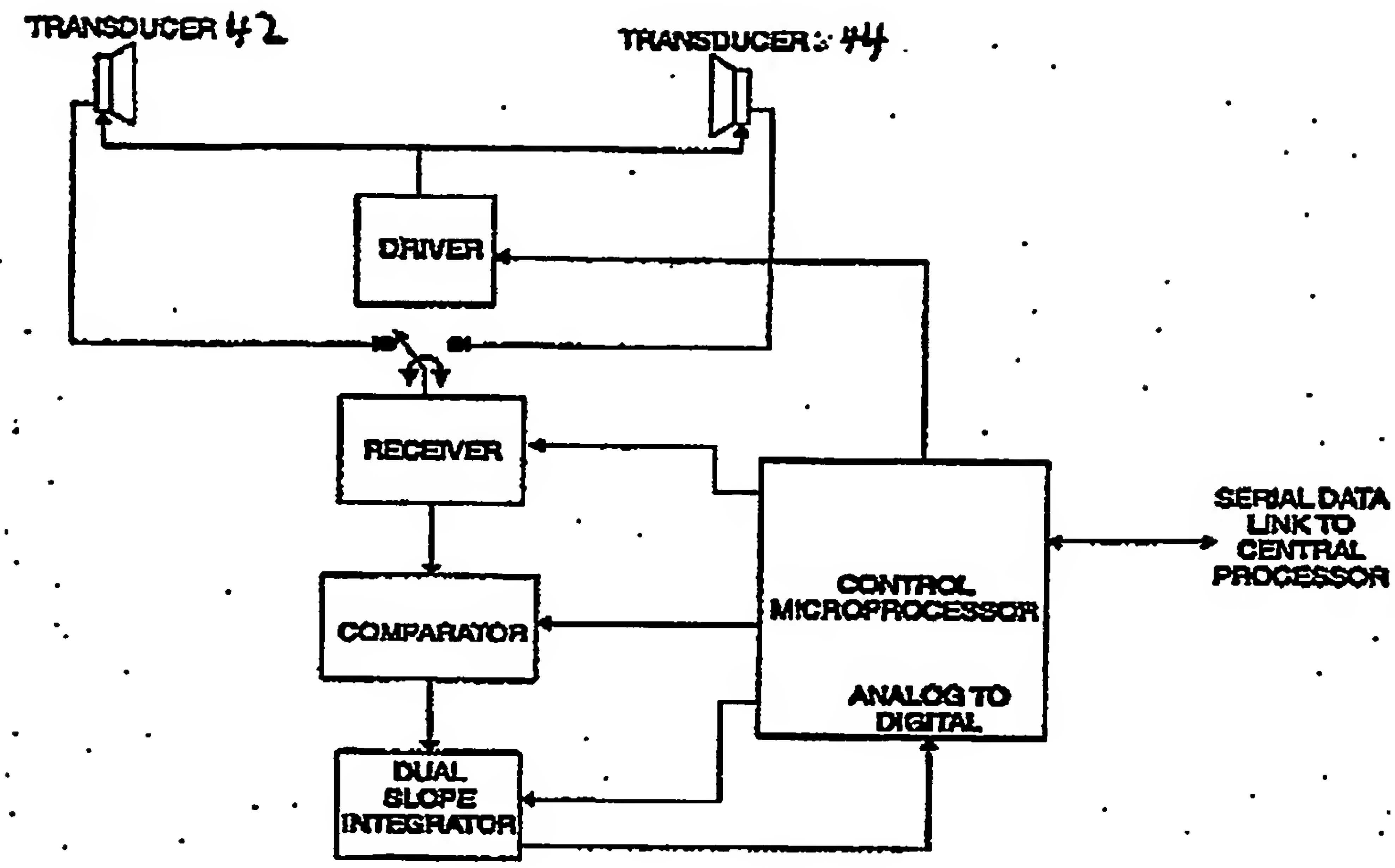

Figure 4

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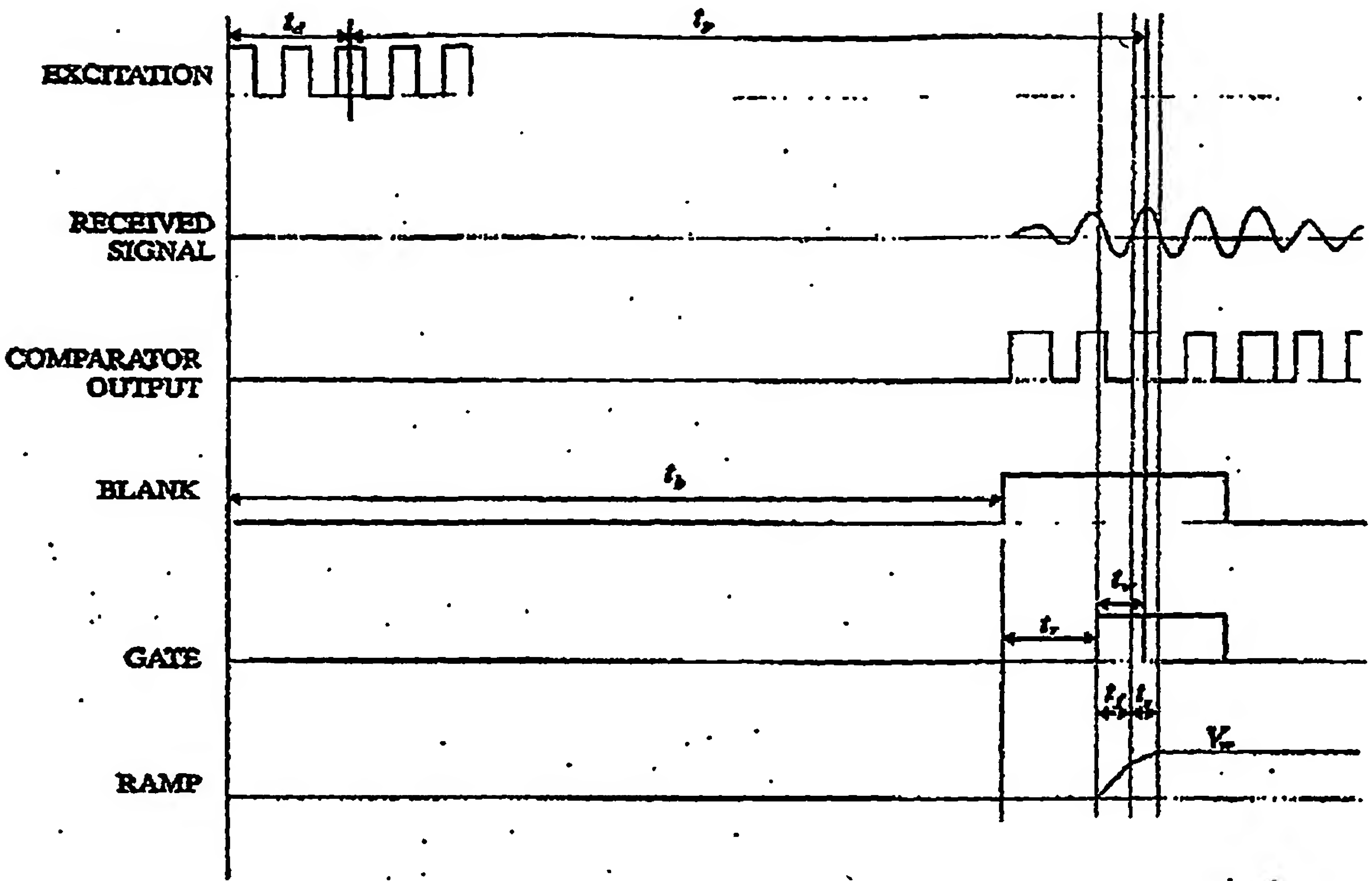
EXCITATION
RECEIVED SIGNAL
COMPARATOR OUTPUT
BLANK
GATE
RAMP

Figure5